An Atlas-Assisted Method for Limited-Angle Cone-Beam Tomography

Sadowsky, Ofri*, Ramamurthi, Krishnakumar, Taylor, Russell H., Prince, Jerry, L.
Johns Hopkins University, Baltimore, MD, USA

This poster presents an atlas-assisted method for artifact reduction in CT-like tomographic reconstruction of anatomy from an incomplete set of cone-beam X-ray projections obtained from a C-arm.

A complete cone-beam reconstruction using standard techniques (e.g., Feldkamp) requires a sweep of (at least) 180 degrees + cone-angle. However, the angle through which a C-arm may sweep is often limited due to patient/O.R. setup. Reconstructed images from such incomplete sweeps suffer from strong limited-angle artifacts because of missing information. Our work is aimed at reducing these artifacts by using statistical knowledge of the patient anatomy to compensate for the missing data.

We present a 3-D reconstruction method that uses an anatomical atlas of a bone as the source of statistical knowledge. Our atlas is constructed from a collection of patient CT scans, and includes the average shape and density of the bone, and statistical variations of both. To perform the reconstruction, we first select a small set of projections from the set of patient cone-beam images, and use them as registration targets in a deformable 2-D/3-D registration. The registration algorithm consists of three steps: rigid transformation, deformation based on the atlas statistics, and local template-matching deformation, while maximizing mutual information. With the registered model, we compute simulated projections of the atlas from those view angles that were missing from the original cone-beam scan. Representation of the atlas as barycentric density polynomials over tetrahedral mesh elements provides a closed formula for generating the simulated projections. We complete the original set of patient images with the set of atlas-based simulated projections and perform a traditional cone-beam reconstruction algorithm on this set to obtain our final 3-D reconstruction.

We have tested our method using a statistical atlas of a hemipelvis and digitally reconstructed radiographs (DRRs) generated from a patient's CT scan for the purpose of patient data. Our initial qualitative assessment shows a significant reduction of artifacts when the atlas is used to complete missing data. Our method combines modeling of biological knowledge-base, in the form of the statistical atlas, and an innovative computational approach in 3-D reconstruction. Improving the accuracy of limited angle-range cone-beam reconstruction can significantly improve patient treatment in emergency or field units.

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